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RESULTS OF THE CARBON MONOXIDE STUDY IN WASHINGTON, D.C., AND DENVER, COLORADO, IN THE WINTER OF 1982-83

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The paper will briefly describe the study of population exposure to carbon monoxide for the residents of the Washington, D.C., area and the Denver, Colorado, area in the winter of 1982-83. The population exposure distributions were determined by direct measurement of CO with personal exposure monitors (PEM's) through the use of statistical inference from a statistically drawn sample. The population of inference for the study was non-smoking, non-institutionalized adults (age 18-70). Each sampled individual carried a PEM for a 24-hour period on one pre-scheduled day in Washington, D.C., and two consecutive days in Denver. The exposure distributions from each study area will be contrasted and factors pertaining to high exposure will be discussed.

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RESULTS OF THE CARBON MONOXIDE STUDY IN WASHINGTON, D.C., AND DENVER, COLORADO, IN THE WINTER OF 1982-83

Introduction

During the winter of 1982-83, the U. S. Environmental Protection Agency conducted a large-scale urban field study to develop and test methodologies for determining, with known accuracy, the exposures to carbon monoxide (CO) of the population of a city. The primary study objective was to develop and evaluate a methodology for measuring the distribution of CO exposures of a representative population of an urban area. Two urban areas were chosen for study; Denver, Colorado, and Washington, D.C. These areas were selected because they differ in elevation, relative CO levels based on historical fixed site data, diversity of land use characteristics and commuter patterns. Approximate dates of field monitoring were November 1, 1982, through February 28, 1983.

Participants in the study were chosen using a 3-stage design. Approximately 3200 households in Denver and 5800 households in Washington, D.C., were screened by telephoning a representative random sample of the population. During the screening process, respondents were asked about their smoking habits, commute times, and other factors which might influence CO exposures. Data from the screener survey made it possible to subsequently create a stratified random sample of individuals with particular characteristics of interest. For example, only non-smokers were selected in the final sample, and persons who commuted long distances were more heavily sampled than were those who commuted short distances.

The exposure measurements were made with a specially designed personal exposure monitors (PEM) with a built-in data logger. The data logger was developed to provide an integrated value expressed in ppm-minutes which was determined by change of activity pattern or automatically on the clock-hour. The clock-hour values were necessary for comparing PEM results with the fixed site results. The interviewer visited the respondent and left a calibrated PEM with instructions for its use and a diary. The respondent carried the PEM recording each change of location and activity in the diary and depressing the data logging button when they changed activity. A questionnaire also was administered to obtain detailed information about the respondent's home, workplace and commute habits. Details of the survey are presented by Whitemore, et al.[1] Other details are reported in the final reports by Johnson[2] and Hartwell.[3]

Study Results

1. Quality Assurance

(a) Precision of PEM Values

The assessment of PEM precision was determined by having a member of the project field staff carry two or more randomly assigned monitors for a 24-hour period. The monitors were exposed to typical sampling conditions of changing temperature, humidity, elevation, etc., as well as to the vibrations and physical shocks inherent in transporting the instruments. In Washington, the mean relative of the standard deviation of the measurement pairs was 30.6%. In Denver, where the average concentrations were higher, the mean relative standard deviation was 14.2%.

Accuracy

Two independent audits of the PEM's were conducted by the Quality Assurance Division, Environmental Monitoring Systems Labor atory, EPA. The first audit was conducted at the start of the pro- ject and the second near the end of the study. Results of both audits indicated that the audited PEM's were within ±10% of the audit gases in both cities.

2. Fixed Site Concentrations

One goal of these studies was to compare exposure results obtained from fixed monitors with directly measured personal exposure for CO. It should be noted that the National Ambient Air Quality Standard (NAAQS) levels for CO are 35 ppm for 1-hour concentrations and 9 ppm for 8-hour concentrations. During the study period the 35 ppm level for 1 hour was never reached in Washington, but it was exceeded in Denver on one day (12/16/82) at one site (<1%). The 8-hour level was exceeded at two Washington sites - one site had one exceedance and the other site had five exceedances (0.5% site-days). The 8-hour level was exceeded at 11 Denver sites (8.7% site-days).

3. Personal Exposures

The field study yielded 712 24-hour exposure profiles in Washington and 900 24-hour exposure profiles (450 persons @ 2 days each) in Denver. The 8-hour maximum results in Denver were approximately twice as high as the levels found in Washington. (The fixed site CO concentrations at Denver were also about twice that observed in Washington.) The Denver personal exposure distribution indicates 10.7% of the 8-hour maximum daily CO exposures were above 9 ppm. This compares to 3.9% above 9 ppm observed in Denver at the fixed sites.

Other results include:

(a) The distribution obtained from the concentrations measured at a combination of fixed site monitors can generally provide a reasonable measure of exposure to CO for the study population over the distribution except for the upper 10 percent of exposure.

(b) Personal CO exposures were higher in microenvironments associated with motor vehicles, such as while commuting.

(c) Personal CO exposures were also higher for persons in high-exposure occupations, e.g., truck drivers, construction workers and garage/service station workers.

(d) In Denver, indoor concentrations were higher than corresponding fixed site concentrations during the time period 0900-1600 hours.

(e) In Denver, the first day and the second day personal exposure profiles are approximately equivalent for workdays.

Summary

From these studies we can conclude that the methodology exists for conducting exposure studies for CO for an urban area. The studies have provided an extensive data base from which statistical comparisons can be performed between population subgroups, between fixed site concentrations and personal exposure, and between indoor and outdoor concentrations. In addition, factors associated with exposures can be estimated and modeled. It is clear that an extension of this concept to other pollutants and other areas over differing time periods (for temporal resolution) is warranted.

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